

AN
Experimental Inquiry
INTO
THE PROPERTIES OF CARBONIC ACID GAS
OR
FIXED AIR;
ITS
MODE OF OPERATION, USE IN DISEASES, AND
MOST EFFECTUAL METHOD OF RELIEVING
ANIMALS AFFECTED BY IT.

BEING
AN INAUGURAL THESIS,
SUBMITTED TO THE EXAMINATION OF
THE REV. JOHN EWING, S. T. P. PROVOST;
THE
Trustees and Medical Faculty of the University of
Pennsylvania,
ON THE 12TH DAY OF MAY, 1797.

For the Degree of Doctor of Medicine.

BY JOSEPH JOHNSON, *h*

OF CHARLESTON, (S. C.)

Member of the Chemical, and Honorary Member of the Philadelphia
Medical Society.

Quam quæ sunt oculis subjecta fidelibus, et quæ
ipse sibi tradit spectator. HOR. DE ARTE POETA.

Philadelphia:
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1797.

D^r B. Duffield
from his much indebted
friend & H^{ble} Ser^t
the Author



TO
DOCTOR E. POINSETT,
Physician of Charleston, South Carolina,

THIS Dissertation is gratefully
inscribed, as a small return for the
many instances of friendship and favour,
conferred on his

Much indebted Friend, and
Sincerely affectionate Pupil,
JOSEPH JOHNSON.

TO
DOCTOR JAMES LYNNAH,
Physician of Charleston, South Carolina.

PERMIT me likewise Sir, in
this manner to testify my acknowledg-
ments for the attention and information
with which you favoured, on different
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Preface.

TO qualify the title of a Medical Pamphlet with the word "Inaugural," is in general to give that pamphlet a title discouraging to the reader's expectations of any thing recently discovered, any thing capable of affording much information, or even much entertainment. For a work thus entitled, is received as a publication of necessity, not of choice, and is esteemed as the production of a youthful mind; consequently, incapable of advancing from its own speculation, truths that hereafter may prove beneficial to the Science of Medicine, and through it, to the great family of mankind.

This general rule, however, has some exceptions; for by the unremitting industry of several Candidates for medical honours, incited to extraordinary exertions by an ambition the most laudable, publications of this kind have appeared superior in justness of theory, in ingenuity of manner, and in genuine utility, to all preceding writings on the same subject; and this, in spite of the usual impediments, from want of time and opportunity to collect, arrange, and compile their observations, with that systematic elegance necessary to make them appear in a point of view the most advantageous.

In this my first publication, many deficiencies may be observed; deficiencies that were unavoidable, they are, however, from having no facts collected on this subject before hand, and from the want of opportunity and time to experiment, as fully as I had wished. The experiments, as may be observed from the dates, were

PREFACE.

all executed, and the compilation made within the space of five weeks; the limited time for its completion.

It was my wish to have repeated the experiments of Dr. Priestley, to ascertain the effects of carbonic acid on vegetation; but the season of the year would not admit it. The Doctor's experiments do not appear to be made with sufficient accuracy*. I had therefore resolved to repeat them, if possible, with distilled water and distilled water impregnated moderately with carbonic acid, using sprigs of mint comparatively in the two waters as in his, and having the other circumstances similar. But satisfied with what I have done; I now submit the work "with all its imperfections on its "head," to the candid inspection of the different members of our Medical Republic.

* He permitted a part of the plant to be surrounded or invested with carbonic air.

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Experimental Inquiry,

&c.

SECTION I.

The manner in which Carbonic Acid operates on the
Animal Body.

IT is not my intention in this Essay, to speak of Carbonic Acid as an object of Natural Philosophy, to enlarge on its history, or show its connexion with the other branches of Science; but merely to view it as a subject of Medical Philosophy. Much has been written on this subject, and very able pens have been, at different times, employed in describing its properties, and showing its uses and effects in the different parts of the creation. Many of the most eminent men indeed of the present century, have thought it an object worthy of their attention, and by experiment and minute observation have completely ascertained its nature, its constituent parts, and its effects on organic matter.

What then, it may be asked, can be my object in undertaking a subject which has been already so amply discussed? I do not mean to repeat what these my precursors have said, to renew their labour, and recite what they have explored:—their writings are in the hands of every one acquainted with books, and familiar to every man of general knowledge. My intention is simply to resume the subject where it has been left unattempted by others, or left imperfect.

I am now therefore to consider its nature as an acid, its component parts, and its effects on the animal body, by an inherent positive power of its own, to be clearly ascertained; and proceed to show the manner in which this effect is produced; from the nature of this, the proximate cause, to point out the most effectual mode of relief; and then show its use in the cure of certain diseases, with the manner in which these good effects are produced.

The opinions of the different writers, therefore, who have attempted an explanation of its effects I shall briefly recite, as preparatory to this part of the inquiry, and offer some observations and objections to each severally as I proceed.

Dr. Priestley, when he published, entertained the opinion that this gas destroyed the lives of animals merely by a deprivation or want of oxigene*; for he speaks repeatedly of the animal's being *suffocated*.

Dr. Goodwyn carries the idea so far, as, in his Dissertation on the Connexion of Life with Respiration, so justly admired, not only to assert, that life was destroyed in a manner exactly similar to that by submersion in water, and in support of his opinion, boldly to declare, that carbonic acid may be breathed in considerable quantities provided it is mixed with atmospheric air; but even to propose inserting its effects as the third species of his Genus Melancœma: but of this I shall speak more particularly, when I come to treat of the cure. Mr. Coleman and Mr. Kite, who published on the same subject with Dr. Goodwyn, and who differ from him in explaining almost every point, connected with the subject of suspended respiration, yet agree with him in believing, that life is destroyed in a manner analogous to drowning.

* This is the language of the present most admired system of Chemistry. Dr. Priestley's literal opinion is, that life is destroyed by the retention and consequent accumulation of phlogistic vapours in the lungs.

To disprove these opinions, it will only be necessary to refer to the comparative experiments of Dr. W. Bache, as published in his Inaugural Dissertation, and to those of Dr. Beddoes, in his Dissertation on Factitious Airs. Dr. Bache found that animals in an artificial atmosphere of oxigene and carbonic airs, expired in 10 or 15 minutes; while others, equal apparently in every respect, lived in the same quantity, by measurement, of atmospheric air for the space of an hour without much inconvenience. Dr. Beddoes found that animals of the same species, of the same litter, and apparently of the same vigour; if immersed in carbonic acid, died in 1 1-2 minute, but in hydrogen not till 22 minutes.

From this we would conclude, that carbonic acid acts by an inherent power; while azote and hydrogen act simply by preventing the influence of oxigene from coming in contact with the lungs; for the length of time which life continues, when the animal is exposed to these two gases simply, is about the same with its duration when the animal is immersed in water.

Mr. Coleman, to support his favorite idea of collapse, asserts, that no more of the noxious air enters the lungs during exposure to it, than of water, in those destroyed by drowning; but this assertion has likewise been disproved by an ingenious experiment of Dr. Bache.

He introduced one end of a syphon into a receiver filled with carbonic acid, the other end of which was fixed, by a bladder and drawing-string, to the head of a dog: he observed the water in the receiver over which the air was collected, to rise and fall alternately as the animal respired. Mr. Coleman's explanation therefore of its effects, by supposing the carbonic acid to irritate the epiglottis, so as to make it close and prevent the entrance of this gas, while the air previously in the lungs is pressed out by the different exertions, and a compleat collapse takes place, being the immediate cause of death; must be wholly unfounded.

But he admits that the noxious airs * do destroy life in a shorter space of time than submerſion in water. And how is it poſſible for this fact to be explained on his principles? is it not indirectly acknowledging, that the noxious airs † have an operation ſpecifically different from that of ſubmerſion in water?

Mr. Kite, although he believes that the proximate cauſe of death from noxious vapours is the ſame with that from drowning and hanging, viz. apoplexy, yet gives it as his opinion that animals, thus deſtroyed, are not acted on in the ſame way; for he juſtly obſerves, that they expire in a ſhorter time and that their limbs continue flaccid for a greater length of time after death ‡. He then goes on to account for this difference in the following words, “ From a variety of circumſtances, I “ am induced to believe, that mephitic air occasions “ apoplexy and death in two ways: firſt, by affecting “ the nerves of the trachia in ſuch a manner, as to “ render the muſcles ſubſervient to reſpiration para- “ lytic; and, ſecondly, by its ſedative property deſtroy- “ ing the action of the brain and nervous ſyſtem.” That the firſt part of this mode of explanation, viz. that the muſcles ſubſervient to reſpiration alone being rendered paralytic, is, independent of the reſt of the body, the immediate cauſe of apoplexy; muſt be erroneous, I infer from the general affection of the ſyſtem, in ſuch caſes of expoſure, and particularly of the ſanguiferous ſyſtem. Hereafter I hope to ſhow, not only that the paralytic ſtate of the reſpiratory muſcles, is not the cauſe of apoplexy, but that apoplexy induced, is the cauſe both of paralyſis in the muſcles of reſpiration, and in thoſe of the whole ſyſtem. As to the ſecond part, viz. that it operates by a ſedative property I hope to demonſtrate to a certainty, that the

* He experimented with the nitrous air of Dr. Priſtley.

† Under the appellation of noxious airs, I would include all gafeous fluids except oxigene, hydrogene, and nitrogene or azote.

‡ See page 210, &c.

reverse of this is true, and that its operation is wholly stimulant.

M. Troja*, who gives the finest history of the effects produced by carbonic acid on the animal body, of any author who has hitherto appeared on the subject, in investigating the nature of the cause which produced these effects, has first instituted an inquiry to determine whether the acid nature of this æriform fluid may not be the property, by which, it so speedily produces death†. After many ingenious comparative experiments with marine acid gas, &c. he proves that this is not the case, provided that its operation as an acid be regarded only as coagulating the blood.

This opinion, I must confess, struck me most forcibly when I first began to reflect on the subject. I observed that all the acids coagulated the blood, and carbonic among the rest; I reflected on the saline taste of the blood; knew that alkalis would preserve its fluidity when removed from the body; observed that solutions of soap, the oily part of which is rendered miscible with water, by its union with the alkaline, were coagulated by carbonic acid, which I supposed neutralized the alkali, so as to disengage the oil from its mixture, and from these considerations I thought it probable that the alkaline matter of the blood preserved its fluidity, and that a coagulum was produced in a manner similar to that of the soap, by the alkaline principle being neutralized. I thought this opinion the more probable, when I knew no reason, why carbonic acid might not act on the blood, through the membrane investing the lungs as effectually as oxygenous gas. This opinion, however plausible it appeared in theory, I was obliged to resign, on seeing the experiment of Girtanner, which shows that venous blood only has its coagulation expedited by carbonic acid, and that arterial blood is not affected

* See Rosier's Journal, Vol I. for 1778, p. 174.

† Ibid. p. 302.

by it. The fact too of the blood in those animals destroyed by carbonic acid, being so uniformly found fluid, was more immediately and more certainly effectual in refuting the opinion.

M. Troja having shown the impossibility of the action of carbonic acid on the blood by its acidity; premises that it can only produce death in two ways, through the medium of the nerves, and through the medium of the blood-vessels, as the agents of the circulation. He concludes from abstract reasoning, that life in cold blooded animals, as frogs for instance, is destroyed by its action on the nervous system. He observes that in frogs, life seems chiefly to depend on the healthy state of the nervous system, and in some degree independent of the circulation; for he adds, "Otez le cœur à une grenouille, & par conséquent la circulation, elle fautera, elle marchera, elle vivra tres-long-tems; coupez la tête à une outre, detruisez sa moëlle epinière, elle ne fautera plus, mais son cœur fera toutes ses fonctions & la circulation se continuera." In hot blooded animals he is of opinion that life is destroyed through the medium of the circulation; and that this is arrested by the frequent respiration which such animals require, being interrupted, for he observes that death comes on before the affection of the nerves could produce disease. He then concludes, "Celles-ci sont les causes les plus immédiates de la mort, des animaux suffoqués par les moffettes: je dis les plus immédiates, & non pas les causes efficientes. Pour connoître en general, la cause efficiente de la mort, il faudroit connoître la cause efficiente de la vie. Consiste t-elle dans l'assemblage des mouvemens? dans l'irritabilité? dans quelque autre chose inconnue la cessation de celle-ci fera la cause efficiente de la mort."

His reasoning, however, is by no means conclusive. That the impression is first made on the nervous system, I can readily admit, but cannot by any means think it possible for life to be destroyed through this system

singly. Neither do I agree that the arterial system can be primarily affected: but that the disease is communicated to it by a reflected impression, is sincerely my opinion.

Fontana, in his work on poisons, and Bergman, who first proved the acid nature of this gaseous fluid*, have declared that life ceases in consequence of the irritability being destroyed. That this is true in its literal sense, I openly deny; for, in all the dissections that I have seen, and in those given by all other authors, the contractility of the heart has been in no degree less, than when the animals are destroyed by other means. But if we consider their assertion in a more general point of view, it will appear to be saying nothing more than simply that *life is destroyed*. For if we believe that the life of an animal depends on the aptitude of its fibres, to receive the impressions necessary to excite the motions of life, it is evident that death must in all cases, equally depend on the loss of this aptitude or susceptibility of impression.

Besides this, if the loss of irritability were the immediate cause of death in the sense that they view it, life could always be restored to a certainty, according to the elegant experiment of Girtanner, by simply inflating the lungs with oxygenous air, as he found the contractions of the heart restored instantly as the air enters the lungs; but this unassisted by other treatment is found to be an ineffectual practice.

Dr. Percival, in an Essay on the Vapours of Charcoal, says they act on the olfactory nerves first, and that the brain and nervous system is affected by sympathy or consent of parts†. He seems to be of opinion that

* The credit of first discovering the acid nature of carbonic acid gas has been given to Mr. Bewley, on account of his Essay published by Dr. Priestley in the 2d vol. of his Observations on Air. The two publications on this subject, it is true, appeared about the same time; but the preference will, by comparing the dates of the experiments, be decidedly given to the Professor of Upsal.

† See Dr. Percival's Essays, Vol. I. p. 338.

these effects on the nervous system are produced by a sedative power; for, although he does not give this idea in express terms, he speaks of its destroying the action of the brain and nerves, and says, "they occasion sometimes all the various symptoms of a debilitated nervous system, according as the poison is more or less concentrated." He himself, however, seems to refute this opinion by advising the common treatment of fever for relieving its effects, viz. bleeding, cupping, blistering and cold air, with frictions, cold water and inflation.

Dr. Bache, who has with great accuracy and ingenuity of experiment, proved unequivocally, the inherent positive action of carbonic acid in the animal body, does not venture to decide on the manner in which this positive action is effected. He suggests, however, several ingenious modes of explaining its effects; he first supposes "an inherent property in carbonic acid gas, inducing, when combined with the blood, whether arterial or not, such changes in its nature as to banish from its dominions all oxigenous gas, according to its state of concentration; causing it to combine with the moving parts of the animal œconomy, to which it is more particularly destined, thereby producing a great accumulation of excitability, which, when acted on by the ordinary stimuli then existing in the system, produces all the phenomena incident to submersion in that fluid." Here the Doctor believes the excitability of the system to arise from the oxigene absorbed into the blood, and indeed to be the same with that principle—a circumstance which yet remains extremely problematical, although Girtanner has given several facts in support of the opinion. He likewise supposes in this, that the carbonic acid absolutely enters into combination with the blood: a supposition which is highly improbable, as many experiments show that immediate coagulation would ensue; but the reverse of this has always been proved by dissection. In a note, he next offers to

explain its operation, by supposing that it acts indirectly on the blood, exhausting the irritability of the muscles, thereby causing a rapid demand for the oxygenous principle, which would be consequently exhausted from that fluid; or, he adds, it may have a compound action, as it may act both directly and indirectly. As these suggestions, however, will not lead to any useful practice, I shall leave them to the unbiassed remarks of others.

In attending to the symptoms apparent in animals exposed to the influence of carbonic acid, I could not but be struck with the sameness existing between them, and the effects described by authors, as attending the exhibition of the most powerful stimuli. To point out this similarity, I will recite the appearances that occur in these cases of exposure: the respiration is first observed to be more difficult, the animal appears anxious, the pulsations are more strong, frequent, and impetuous, so much so indeed, that M. Troja, who first noted the appearance, has very descriptively compared the sensation communicated, to that of a column of mercury pressed by injection, with the greatest possible force. The animal becomes dull; a violent head-ach comes on; the head, neck and eyes, appear turgid; the pupils are greatly dilated; a sickness occasionally occurs; languor and coma come on; the heat of the body is greatly increased; convulsive twitchings succeed; languid, slow, and irregular pulsations are now observed; the heart appears but to thrill—and its action ceases forever. That these symptoms are justly stated, I appeal to the observations of others, which have been confirmed by the different cases to which I have attended. No one who reads these symptoms, can fail of being impressed with the similarity existing between them and the effects of opium. Dr. Crumpe, in his admirable treatise on opium, in describing its effects on the body, when taken internally, states the pulsations of the

heart and arteries as rendered quicker, fuller, stronger, and more frequent, but that they afterwards sink to be slower than before the dose was taken. That head-ache, an increased flow of sweat and urine, increased heat, tremors, vertigo, stupor, and a dimness of sight, as in the case of Dr. Ramsay, published by Dr. Leigh, and quoted by Dr. Crumpe; then follow laborious and stertorous respiration, intermissions in the pulse, and death*. That opium is a stimulant I think incontestably proved by the exertions and ingenuity of Drs. Leigh, and Crumpe; and that a substance which produces effects exactly similar, must have properties exactly similar, will, I think, be acknowledged by every one. That carbonic acid does produce effects, not only similar to those of opium, but likewise to those of other substances, acknowledged to be stimulants, I hope to make evident.

Does volatile alkali, which is universally acknowledged to be a stimulant, by its application produce an increased action of the pulse, and increased heat of the body, head-ache, vertigo and death? so does carbonic acid. Does the datura stramonium produce nausea, giddiness, pain in the head, dilated pupils, &c.? so does carbonic acid. Do ardent spirits, increase the pulse, elevate the mind, produce an increased disposition to agility, induce vertigo with all the symptoms of intoxication and coma? so does carbonic acid, as I hope to prove.

The matter, however probable it appears from analogical reasoning, and from casual observation, has not as yet been fairly proved by the test of experiment, the unerring touch-stone of truth. Dr. Dobson, it is true, in his much admired Treatise on Fixed Air, has strenuously supported this opinion, and has compared its operation to that of electricity, which is now universally acknowledged a stimulant. He has likewise attempted to prove it by experiment; but, unfortunately these experiments are by no means conclusive;

* See Crumpe on Opium, p. 9.

as the results may as well be ascribed to the impressions of the ingredients used, as of the gas disengaged. He swallowed certain portions of vegetable, and of volatile alkali, immediately on being mixed with a quantity of lemon juice*, his pulse was in consequence raised in the space of 15 minutes, from 74 to 80 strokes in a minute, with a slight vertigo and glow, attended with nausea. That the alkalis and acid, (both of which are acrid substances) had considerable influence in producing these effects, may, I think, be reasonably urged; as Dr. Dobson, who ascribes the whole of the effects to the carbonic acid disengaged, concludes that the quantity of fixed air disengaged from that proportion of the materials, is as great as the stomach can bear, from the degree of nausea that was induced; but Dr. Falconer, in his note to this part, mentions, that he has taken, and has given to others, double the quantity there mentioned, without producing the smallest degree of nausea.

To avoid an interruption of this kind, I thought the intention would be fully answered, by a sufficient draught of aerated water, for here no acrid substance in the mixture could interfere with the result, nor afford to the most severe scepticism the slightest chance for evasion.

With this intention, I procured some water impregnated to a moderate degree with carbonic acid, by Priestley's apparatus: its taste was not equal in briskness with those of Saratoga, agreeably to the opinion of a friend who had visited that place. March 21st, my pulse beating 72 strokes in the minute, I drank about 10 $\frac{3}{4}$ of this water; in the space of 5 minutes, it had increased to 76, in 10 minutes, to 80, in 20, to 84, in 26 it beat 84—in 36, it fell to 76, in 46, to 72, in 56, to 68, in 60, to 64, and in 70, it beat 64. In

* Hetook $\mathfrak{D}$ ii. gr. iii. of salt of tartar at once, and $\mathfrak{D}$ i. gr. v. of volatile alkali at another time, each being mixed with $\frac{3}{4}$ of lemon juice. (See Dobson on Fixed Air, p. 19).

this we see the pulse increased in the space of 20 minutes, from 72 to 84 strokes in the minute, simply by the draught of little more than half a pint of carbonated water. In 10 minutes, when my pulse had increased to 80, my spirits were very sensibly elevated; but this I was unwilling, without further proofs, to ascribe to the carbonic acid: my pulse had now likewise increased in fulness and strength. In 26 minutes, when at 84, it was very full and strong, the heat of my body was considerably increased, and accompanied with a sense of distension and turgescence in the head. When it fell to 72, my head began to ache, and my pulse became weaker, and less full; and when it fell to 64, I became dull, heavy, and much inclined to gape—the head-ache continued. Here too, it may be observed, that the pulse, at the end of the hour, fell 8 strokes in the minute below its natural standard; a circumstance that was wholly unattended to by Dr. Dobson, and which is a material consequence, as it so evidently strengthens the analogy of its operation to that of acknowledged stimulants.

These results I was led to expect from the information given me by my friend and fellow graduate Dr. S. Cooper, respecting the effects of the acidulous waters of Saratoga. He mentioned that he had uniformly observed an increased flow of spirits, on taking a draught of these waters, with an alacrity to which he was a stranger without it; his sensations always, on such occasions, corresponded with those attending the use of a moderate quantity of wine. In this respect, too, he observed it to resemble diluted wine, that it never did, although taken in large portions, produce that heaviness and oppression at the stomach, which is observed to attend a large draught of common, or spring water. The disengaged air, it is probable, stimulated the stomach, like the diluted wine, so as to promote its own discharge. Dr. Seaman, who has with much accuracy analyzed these waters, in speaking of their medical virtues, has like-

wife very expressly declared, that “in some persons, “they induce a degree of inebriety similar to wine; “they generally increase the appetite.”

This experiment was repeated frequently, and always with the same results, viz. an increase in 20 or 25 minutes, of pulsations from 8 to 12 in the minute, and as uniformly a diminution at the end of the hour, of from 4 to 8 strokes in the minute.

I thought it necessary, however, to repeat it in a larger proportion. March 23d, having prepared some water impregnated with the acid, somewhat more highly than the last; I drank a little better than three half pints, my pulse beating 60 strokes in the minute. My pulse, in

5 minutes, beat 60

15 64

25 68

35 72

45 76

55 84

65 80

80 72

95 64

120 60

In 25 minutes after taking the draught, when the pulsations were 68 in the minute, my pulse had evidently increased in fulness and strength. I now felt more cheerful, with a disposition, as I thought, to be mischievous. When from 76 to 84, it beat violently, with a throbbing in my temples, a disposition to vertigo, and occasionally, an unconsciousness of what I was doing. When it returned to 80, it was weaker, and less full; when from 72 to 60, I became dull, languid, and sleepy; when to 60, I was no longer able to refrain from dosing, and actually fell asleep while feeling my pulse.

Having previously dissolved three ounces of sugar in seven ounces of water, with the addition of half an ounce of yeast, it had just now commenced a moderate

fermentation. I therefore, immediately, while my pulse was at 60, from the effects of the previous portion, drank this fermenting mixture. My pulse, in 5 minutes, beat 64

10	67
15	72
20	72
30	76
40	72
55	60
70	56

I now ceased to observe its variations. My sensations, during the operation of this draught, were, in some respects, different from those of the preceding. My heaviness, and dull head-ache, left me as my pulse rose, and when it was at 76 I felt cheerful and calm. A slight head-ache, however, succeeded, but no dullness, or disagreeable sensations; in the morning after, I felt as languid as if I had been using severe exercise; my head felt heavy, and my eyes were dull, and somewhat swollen.

Knowing it to be very difficult to excite intoxication in myself, I prevailed on a friend, who was somewhat more irritable, to take of the same water, that had produced the last, and most remarkable effects on me. He drank a pint of it, which, in the space of 25 minutes, raised his pulse from 88 to 96; and, at the expiration of the hour it fell, as it had risen, through all the usual changes, down to 76. While it was rising from 92 to 96, his pulse became fuller and stronger, attended with a throbbing in his temples, and a sense of warmth from his stomach, diffusing itself through his body. His pupils were now greatly dilated, and an evident vertigo came on; so that objects appeared to rotate, and dance before his eyes. Here it was remarkable, that immediately after each accession of vertigo, his pulse fell 3 or 4 strokes in the minute; but soon after, resumed its former force, increasing till another attack of vertigo came on.

He seemed much alarmed at each sensation of this kind, fearing that he should fall, or be injured by the objects apparently moving about him; to this fear I ascribed the sinking of his pulse, which returned to its increased state of action from the influence of the carbonic acid, till another attack was produced.

Having now ascertained its action on the body, through the medium of the stomach, I thought it necessary to determine whether it would produce effects of the same kind when thrown into the intestines. March 22d, I injected into the rectum of a friend, by means of a bladder and pipe, about half a pint of carbonic acid gas; his pulse being previously found to beat 58 strokes in the minute. Here the results were different from what I expected, and different in some respects from those in the preceding experiments, but not less satisfactory. His pulse did neither rise nor fall in the regular order there described, but would increase only in proportion as he observed the air pressed downwards, by the peristaltic action of his intestines, and irritating the sphincter to be discharged; it then rose 6, 8, and 10 strokes in the course of 6 or 8 minutes, and would fall again gradually as this subsided. His pulse once was observed to beat 68 strokes in the minute, and had increased proportionably in fulness and force. He then complained of considerable uneasiness in that part, and a smart head-ache—his pulse, after these sensations went off, sunk to 52 *. These variations were observed to continue until the air was discharged.

From these appearances we not only conclude, that carbonic acid gas acted as a stimulant to the

* Dr. Dobson has taken no notice of the pulse in his experiments, after it descended to the original standard. In these, however, we find an additional proof of the stimulating operation of carbonic acid gas; a proof advanced by the strictest analogy, with the effects of substances acknowledged to be stimulant—I mean the uniform sinking of the pulse below its natural state, after the increased action had ceased.

arterial system, through the medium of the rectum, but of the rectum alone compared with the other intestines; for the pulse actually fell below the natural standard when the air returned to the colon*.

As most of the stimuli, which produce their greatest effect when applied to the stomach, will likewise produce some effect on the body by their influence through the skin; it appeared highly probable that carbonic acid would affect the body through this as a medium, in a manner similar to these last noted. I was especially led to this expectation, by reflecting that the lungs, through which its greatest impression is made, should be considered merely as an extended portion of the external surface of the body. Landriani, indeed, has given an experiment which, if it had been proved just, would be decisive in the question; but the experiments of M. Troja †, and those related by Dr. Bache ‡, disprove the accuracy of his decision.

In cold blooded animals, however, as frogs for instance, M. Troja tells us he found the fact strictly true, viz. that life in them was destroyed by the exposure of the body singly to the influence of carbonic acid gas, the animal breathing freely in atmospheric air during the whole time, by means of a tube fixed by ligatures in the trachia. If life then is destroyed in animals supplied with lungs and well formed respiratory organs, by the exposure of the body alone to the action of carbonic acid, it would surely be affected to some degree by the same exposure, in other animals that are only different in having these organs more completely formed.

* Does not this point out the necessity of having those injections, which we wish to act by stimulating the body, comprised in as small a bulk as possible, that being merely thrown within the rectum, they may there exert their stimulating power fully, without provoking by their bulk the increased peristaltic motion of the other intestines, so as speedily to be returned.

† See Rosier, p. 218.

‡ See Bache, p. 18.

In order to prove the justness of these speculations ; March 4th I found my pulse to beat while sitting up, 76 strokes in the minute. Then stripping I got into bed, and having fixed the clothes in contact with my body, sufficiently close and uniform, I discharged from four bladders introduced in succession under the bed-clothes with care, carbonic acid to the quantity of about two gallons. My pulse rose in

5 minutes to	81
10	84
15	86 ;

my face began to burn, and I was sensible of a considerable head-ache. These appearances were not sufficiently satisfactory to my mind, as they may be supposed to arise from the greater warmth of the bed ; even the increased frequency of the pulse may be ascribed to this cause, although it should have been less in the recumbent position, which I then preserved, than while sitting up.

To give the matter a fair trial, March 6th, I stripped to my shirt, and entered a brewer's beer tub which had not yet been cleared of the carbonic air so a ke liquor was run off. My pulse which before I by emi was found to beat 84 strokes in the minute, stood at

2 minutes at	84
5	88
10	90
15	120.

The atmosphere of carbonic air extended, as I found by the extinction of a candle, no higher than about the pubis ; I therefore at the end of 10 minutes kneeled down, that my body likewise might be invested by it : then followed the remarkable increase. The weather was rather cold, and although naked, I did not feel any inconvenience from my exposure, being warm indeed, or at least, very comfortable in every part except my hand which was held up, while my friend Dr. S. Cooper attended to my pulse.

It might be objected, that these effects were possibly produced by inspiring a portion of the carbonic air at the time; but this I cannot admit, as the carbonic air was found by the test of the candle to hold, from its gravity, that determined height, as effectually as a fluid of still greater specific gravity, as water for instance. I am unwilling to admit it likewise, because my respiration during the whole time was perfectly calm and free, being no ways laborious or difficult, which certainly would have been the case, had the impresson been made on the lungs. When between 10 and 15 minutes in this situation, I was sensible of a prickling on my legs and thighs, which probably was occasioned by the action of the surrounding medium; but this I will not urge, as the same has been observed from the motion of the hairs, &c.

To prove the stimulating operation of carbonic acid in another point of view, April 5th, I filled a small glass, (of a proper size to inclose or cover with its mouth the surface of my eye) with carbonic acid by means of a syphon, and I applied it to my eye while ^{the} true, ^{the} smarting irritation was so considerable ^{the} exposed ^{the} half a minute the tears flowed rapidly; in one minute, however, it began to abate and in 1 1-2 minute I felt no more inconvenience. I then applied to my eye while open, a stream of this gas issuing from powdered marble and diluted vitriolic acid mixed in an oil flask. In 1-4 of a minute the irritation was evident, but continuing the application for 1 1-2 minute, the smarting and pain was so considerable that I could no longer endure it. My eye was now greatly inflamed, all the blood vessels of the Tun. Conjuncta being distinct and turgid with blood, the whole surface of the opaque Cornea was covered with blood vessels.

March 19th. In a puppy that had been strangled, the thorax was opened and the heart shortly after began to act, but ceased at the end of 1 1-2 minute. The carotid artery was then opened, and a small aperture being made in the pericardium, I injected carbonic acid

into it by means of a bladder and pipe; the heart instantly renewed its contraction, and the blood began to flow from the carotid artery where divided.

As carbonic acid gas more frequently affects the animal body through its influence on the lungs, I found it necessary to attend more particularly to its mode of operation when inhaled, than had hitherto been done. Having mixed 1-3d, by measurement, of carbonic acid gas with 2-3ds of atmospheric air, in a bell-glass over water; I introduced a curved tube of sufficient size to admit of free respiration, and inhaled the mixture; the expiration was made through my nose, which I closed at each inspiration.

My pulse which was previously found to beat 76 strokes in the minute, suddenly increased in fulness, force, and frequency, as I became sensible of the carbonic acid having affected my lungs; so that at the end of 1 1-2 minute it beat 100 strokes, having increased 24 in that short space of time. My body, which was not warm before this, now burned with a glow of heat, and my head seemed turgid with blood.

March 10th, I inserted the same tube into a keg that had been filled with carbonic acid gas, by emptying water from it into a brewer's tub which had just been drained from beer. On inspiring as before, through this tube, my pulse which beat 64, rose in

1-2 minute to 72

I 78

I 1-2 86

A friend inhaled this when much diluted with atmospheric air, his pulse beating 72 in the minute; it rose in

1-4 minute to 76

1-2 78

I 80

I 1-2 84

It appeared proper, however, that I should vary this experiment; that I should throw aside the tube and breathe in this air, freed from the inconvenience of its travelling through so great a length of canal, and

in a manner wholly natural. To effect this, I entered March 6th, into a brewer's tub which was about half full of carbonic acid gas, disengaged by the fermentation of beer, of which it had just been emptied.

My pulse beating 84 in the minute, I stooped and inhaled the carbonic air immediately from its surface, where in contact with the atmosphere. Immediately my pulse increased in fulness, tension, and force; and was found to beat 100 in the minute, having become bounding and irregular*. My respiration became exceedingly difficult, laborious, and stertorous; my body which before was not warm, now burned with a glow of heat attended with profuse perspiration; my temples throbbed; my neck and head seemed greatly distended, and turgid with blood; and, in short, my sensations were those of the most excessive plethora that can be imagined. My eyes now seemed violently distended, and my sight became dim, and almost entirely lost—the loss of sensation would probably have been the next in succession†. During the whole of these violent symptoms, my mind continued calm and perfectly rational; I attended to the different sensations and their order of accession; and among these a circumstance that clearly evinces the stimulating operation of this gas, could not escape my notice. I observed during the commencement and progress of the plethoric

* Dr. S. Cooper attended to these changes as they occurred.

† This has previously been tried by that intrepid, but unfortunate experimenter the young Pilatre de Rosier. The only account of which that I have been able to find, is in Chaptal's Elements of Chemistry, related as follows. "He caused himself to be fastened by cords fixed under his arms, and descended into the gaseous atmosphere of a back of beer in fermentation. He had scarcely entered into the mephitic before slight prickings obliged him to shut his eyes; a violent suffocation prevented him from respiring; he felt a giddiness, accompanied with those noises which characterize the apoplexy: and when he was drawn up, his sight remained dim for several minutes; the blood had filled the jugulars; his countenance had become purple; and he neither heard nor spoke but with great difficulty; all these symptoms, however, disappeared by degrees."

symptoms, an evident distension, and nearly compleat erection of the penis, which subsided on my rising and removing myself from the action of the cause*. A smart head-ache came on after this, and continuing for half an hour, then abated; but did not entirely go off during the whole day—I continued somewhat languid for this and a part of the next day.

It is an opinion almost universally adopted by medical philosophers, that cold has an operation on the animal body, according with the idea conveyed by the term sedative†; that is, an operation suited to counteract, prevent, or remove the effects of stimulating substances. If this be received, the reverse will likewise be true, viz. that stimulating substances will counteract the effects of cold, and this will not, I expect, be denied by any one. To take advantage of this consideration, and prove in the most decided manner possible, that carbonic acid gas acted as a stimulant on the animal body; I caught March 24th, two young mice of nearly their full growth, of equal size, of equal strength apparently, and probably of the same litter, as they were taken together in the same trap. I exposed them in 2 oil flasks to a refrigerating mixture‡; the mouse A. in simple atmospheric air, the mouse B. in an artificial atmosphere, composed of 1-3d, by

* May not this become a safe and efficacious article among those of the *Materia Medica*, called *Aphrodisiacs*; the person into whose rectum the carbonic acid gas was injected, very pointedly noticed the same appearance, and ascribed it to the same source.

† The term is here received in compliance with the usual language of physicians, although I entertain doubts of its propriety; for I cannot conceive of a substance producing a real impression on the animal body, unless that impression be made by a kind of irritation, which must be the effect of a positive stimulating action. Dr. Cullen defines sedatives, “those medicines suited to reduce the motions, or power of motion, in the body.”

‡ This was made by the solution of 11 parts muriate of ammoniac, 10 parts nitrate of pot-ash, and 16 parts sulphate of soda, in 32 parts, by weight, of water; the thermometer stood at 24° while they were dissolving.

measurement, of carbonic acid gas, and 2-3ds of atmospheric air mixed intimately by agitation with a small quantity of water.

The appearances noted were as follow :

in 5 minutes—both very uneasy, and jumping vigorously to effect an escape.

8 A. seems asleep, B. still jumping.

10 A. still moves, but is lying on his side, B. is scratching, and attempting to climb the sides of the vessel.

11 A. is dead, B. still scratching the sides of the vessel.

15 B. is just motionless.

These results prove to a certainty, that the carbonic acid in the mouse B, where all other things were equal between the two, prolonged its life by a stimulating operation, for the space of 4 minutes in 15 beyond that of its fellow A.

This being, I hope, established, I proceed in the next place to explain my opinion of the manner, and order in which life, through the medium of the different parts or sub-systems of the body, is influenced by carbonic acid gas. Of these I believe its immediate and primary operation, like that of opium, is exerted on the nervous system; by the nervous system its stimulating effects are communicated to the muscular fibre, and is there made evident, by the consequent increased action of the arterial system, which does, and must invariably, take place. The increased arterial action being disproportioned to the strength in the other parts of the body, and in the brain particularly, there produces congestion and effusion, by which apoplexy being induced, the functions of the animal body are instantly arrested.

That its first operation is on the nervous system, I infer from the action of this being most violent on the

lungs, which are known to be little more than a mass of cellular matter, but capable of communicating impression. To illustrate this by analogy I will only instance the immediate increase of the pulse on taking into the stomach a portion of ardent spirit or laudanum, or by the impression of volat. alkali on the sniderian membrane all which effects must surely be produced through the medium of the nervous system.

If an objection be made to the possibility of stimulating the system by an impression on the lungs, I would obviate that objection by observing that the body is as truly nourished, in some respects, by the lungs, as by the stomach. If oxigene be admitted as necessary to the very existence of the different parts of the body, and even of the bones*; and if it be admitted that this is received into the body through the lungs in respiration, the observation is just. But the stomach is not only furnished with the power of supporting life by supplying the body with nourishment; but likewise of being a part capable of receiving and communicating impressions made on it by stimuli, so as to prolong life when it would otherwise sink for want of nourishment†. Who then can doubt of the lungs being capable of communicating impressions like the stomach to the rest of the body, when like it, the lungs are found to have a very powerful agency in supporting the system by supplying nourishment. The effects produced by exposure to the vapour from spirits, are exactly the same as those of which we have been speaking, viz. head-ache, vertigo, &c.; the manner in which they are produced must likewise be the same in every respect.

* The bones of animals consist of phosphoric acid and calcareous earth—the phosphoric acid is composed by the union of oxigene with phosphorus; without this principle, therefore, the bony fabric could no longer avail in giving solidity to the body.

† The inhabitants of Asia, and of India more especially, are supported for weeks in the time of famine, by the use of opium alone. (See Lind on the diseases of hot climates.)

Oxigene is known to give force and strength to the circulation; its mode of effecting this, however, I believe to be essentially different from that of carbonic air: the one acts by being absorbed into the mass of blood, and thus imparting to it that property, by which it is capable of affording the stimulus to the heart and arteries which is necessary to keep them in motion; the other, as mentioned before, by stimulating the nervous system.

It has been advanced as an objection to the stimulating operation of carbonic acid, that mead, in which this acid abounds, is incapable of producing intoxication. A fact like this, if just, would indeed prove a powerful argument against the probability of our opinion. That the assertion is made without foundation, and that it is erroneous, I am satisfied by the information of a friend whose accuracy of observation and candour in science, has been uniformly admired by his acquaintance. He told me in the presence of several of my associates, that he had repeatedly observed vertigo to a considerable degree produced in himself by drinking mead*. That I might, however, be confirmed in this by my own observation, I drank April 5th, about $\frac{3}{4}$ 12 of brisk mead. My pulse previously beating 84 in the minute, was found in

3 minutes at	86
10	90
20	80
30	78.

In a friend whose pulse beat 92 in the minute, it rose in the space of 10 minutes to 100, and on sinking at the end of 20 minutes to 90, was restored by another copious draught to the number of 100; this increase was observed, although our pulses should have sunk without the draught, because we had just come from

* This I have stated in a pointed manner, because of my not having had an opportunity of being much acquainted with the effects of mead when drank to any quantity: the same may be familiar to others.

walking in a warm sun, and were then sitting still in a pleasant situation.

That this increased arterial action does take place, I prove by the state of the pulse, which has always been noted; from the increased heat of the body, and from the blood being found fluid or dissolved on dissection: this we can only explain by considering it disorganized, torn, and rent to pieces by the excessive action of the vessels.

That apoplexy is the immediate cause of cessation in the vital functions, I infer from my own sensations of plethora about the head; from the turgescence of the neck and face, from the distended or projected state of the eyes, the dilated pupils, the coma, the stertorous and laborious respiration; from the dissections of animals thus destroyed as described by authors; they mention the blood-vessels of the brain as turgid with blood, with bloody serum occasionally effused in the ventricles, and from those of my own, where, in addition to these I found red blood effused between the dura and pia mater. Lastly, from observing a paralytic affection of the fore and hind leg, on the same side of an animal that I had restored to life. That this is the case, I further prove, from the case related by Dr. Percival, of a cook who exposed himself over charcoal fires; he was afflicted for a year with acute pains in his head, which were followed by a paralytic affection of his limbs.

These opinions, I am the more inclined to support, from the propriety of practice to which they lead, in relieving animals apparently dead from exposure to the influence of carbonic acid gas.

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SECTION II.

The method of relieving Animals apparently destroyed by
Carbonic Acid Gas.

THE opinion of life being destroyed, in these cases, by the simple absence of oxigene; I hold to be improper, not only for the reasons advanced above, but likewise on this consideration, that it leads to inert and even injurious practice; injurious, as it would exclude the use of more powerful and efficacious remedies. If this were just, the simple inflation of the lungs, with atmospheric air, would effectually remove the disease; but unfortunately the reverse of this is true. Dr. Bache gives the case of a mouse and a dog that continued to breath, the mouse for five minutes, and the dog three times, after they were removed from the influence of this air*. Dr. Percival quotes two cases of the same kind†: “a prisoner who had been exposed to the vapour of charcoal was found pale, speechless, and without motion; afterwards he spoke incoherently, was seized with a fever, and died. Two boys went to warm themselves in a stove room heated by charcoal; in the morning they were found destitute of sense and motion, with countenances as composed as in a placid sleep. There were some remains of pulse, but they died in a short time.”

From these cases it is plain that pure air inhaled, can have no effect in restoring life. No assistance was offered them as far as we can learn, and it is evident, that if the depressed state of the system was not relieved by evacuants, death must ensue with equal certainty, that it would in a similar state from common fever. If carbonic acid acted by destroying or abstracting the irritability, it would here be certainly restored, according to the experiment of Girtanner,

* See p. 65.

† See p. 337. Vol. I.

which shows that the contractibility of the heart immediately returns as the air enters the lungs.

Mr. Kite, whose opinion on this subject we have already noticed, in speaking of the cure*, recommends inflating the lungs with pure or deplogisticated air, "which, he observes, seems well adapted to neutralize" and correct all kinds of mephitic effluvia." But as this is not at all times easily procured, he advises simple atmospheric air, and adds, "I think it will answer" this purpose very effectually; for the affinity which "exists between phlogisticated and deplogisticated" air is so great, that the deplogisticated portion of "the atmospheric air will combine with the mephitic" vapour; and by frequently repeating the operation, "its noxious property will soon be sufficiently altered." How great a want of chemical knowledge is here betrayed! no one of the gases, except the nitrous air of Dr. Priestley, has any change effected in it, by uniting, as it would in the lungs, with oxygenous air; and in this one case a horrid change indeed, for the worse, would be produced, as nitrous acid gas would be instantly formed.

For relieving the effects of carbonic acid he advises the vol. alkaline air to be inhaled with the same intention, viz. neutralizing and correcting its acid property. This idea must surely be looked on as ridiculous, for alkaline gas being itself a powerful stimulant will produce effects exactly similar. As well might he, if called to a patient who had swallowed caustic alkali, (for it is on the same principle precisely) think of pouring the vitriolic or nitrous acid down his throat to correct its caustic nature.

As the cure of all diseases depends in a great measure on the justice and accuracy of the ideas we entertain respecting the nature of their proximate cause, I would reject these ideas as highly improper. It has been shewn that animals die after being exposed to carbonic

* See Kite's Essays, p. 213.

acid, although they had been removed while breathing; if the above principles were just, it could not have ceased, as the blood continued to be supplied with vital air by respiration. But if it be believed, that death is produced by the violent impression of a very powerful stimulant on the body, occasioning an affection of the arterial system, similar to that in the most inflammatory state of fever; and that this stimulant excites a peculiar determination of the arterial action to the brain, we will then not only arrive at a complete explanation of all the phenomena, but likewise have a fair and pleasing prospect laid open before us for relieving its most dreadful consequences.

In violent attacks of synocha fever, we immediately prescribe cold applications and copious blood-letting; in cases of apparent death from apoplexy we prescribe copious blood-letting without hesitation, and with effects the most evidently advantageous. In affections then of the same nature exactly, although excited by different causes, the same treatment should without hesitation be adopted. As the head is found, from the phenomena of death and the appearance on dissection to be the seat in which the greatest disease exists, our efforts should be more immediately directed to the relief of that particular part. For this purpose the jugular vein or temporal artery should be opened and ice applied to, or cold water thrown over the head more especially, and likewise the whole of the body.

To prove the propriety of this practice, March 7th, having destroyed a cat by immersing it under water into a bell-glass filled with carbonic acid gas, procured from powdered marble and diluted vitriolic acid, it was withdrawn after being exposed 3 minutes, and 1 minute after it ceased to show signs of life. In 3 minutes after the application of the ice, its heart began to beat, cold water was now constantly thrown over it, its respiration became evident and constant, and in 5 minutes it made an attempt to rise. The pupils of the eyes which had been greatly dilated, now contracted

to nearly their former size, and the body became exceedingly hot, the cold water continued to be thrown over till it ran about freely. When the cat had thus far recovered, we immersed her as before, and withdrawing her after the same length of time, cold was applied in the same manner for the space of 4 minutes before her heart was found to pulsate; when one inspiration was observed, we opened the jugular vein with a lancet; immediately on the first discharge of blood she began to move, her pupils now contracted rapidly, and the heat of her body as before was greatly increased. The pulse was now found to beat rapidly, being at 200 strokes in the minute, and in 4 minutes after had descended to 152; she then moved about the room, but with evident paralysis of the extensor muscles, the fore and hind leg indeed of the left side was evidently paralytic for a length of time. Here the effects of bleeding were so decidedly beneficial as to enforce attention, even if we were not satisfied of its propriety, in reasoning from first principles; for when the blood began to flow she moved her head and attempted to rise.

In addition to this Dr. Bache informed me, that in one case, he restored life to a cat that had been confined in carbonic acid for the space of 15 minutes, 12 at least, after life had to all appearance ceased, by the application of cold water, it being frequently dashed over the body.

Dr. B. Duffield, of this city, has obliged me with the history of a case of asphyxia from the same cause in which the treatment here recommended, was proved in the clearest light possible, to be completely successful. * "A young man 18 years of age, by name Isaac Turner, apprentice to Nicholas Pickles, being healthy and robust, was prevailed on by the promise

* This the Doctor was so obliging as to dictate while I committed it to paper.

“ of 6 doll. to attempt the recovery of a watch
 “ belonging to a French gentleman, which had fallen
 “ into an old confined and filthy necessary. He
 “ descended by a rope fixed round his body, and
 “ instantly sank to his waist in the filth below. He
 “ then stooped and began to stir about, and groop for
 “ the watch; by which motion it is probable he disen-
 “ gaged a large quantity of the noxious vapour by
 “ disturbing its retaining cause, and by his position
 “ inhaled a larger quantity of it than he would have
 “ done if erect. He informed me after recovery, that
 “ he had not stirred the filth more, as he imagines,
 “ than one minute, when (to use his own words) his
 “ head began to turn round, his stomach to be so sick
 “ as nearly to cause fainting; and his breast seemed
 “ to be buckled round with a broad strap, so as to
 “ prevent his breathing. In this situation he called
 “ with a hoarse voice to his assistants above, ‘ for God’s
 “ sake! hoist me out;’ but they ignorant of his situ-
 “ ation, neglected him, as an intelligent man present
 “ supposed, for the space of 5 minutes, when finding
 “ the rope much tightened, and not moved, they drew
 “ him up covered with filth, pale, and apparently dead.
 “ He was carried to his master’s house, and I saw him
 “ in about the space of 5 minutes more. Being strip-
 “ ped, (which was easily done, as he was remarkably
 “ limber and flaccid, no appearance of life remaining
 “ but the natural warmth) I ordered two men to stand
 “ with buckets, and dash water over him constantly as
 “ he lay on the floor, the one over his head and body,
 “ the other over his extremities, and the water to be
 “ constantly supplied fresh as it was used. In a few
 “ minutes he was in a cold bath completely, for the
 “ the floor was inundated with water, the windows
 “ had previously been opened; the water continued
 “ to be dashed cold over his body, and in 20 minutes
 “ the heart seemed to resume its functions; in 30 a
 “ feeble pulse was observed in his right arm. Shortly
 “ after he opened his eyes, and in the course of

“half an hour more his speech returned; his pulse
 “had now increased rapidly, and he begging to be
 “let alone, the dashing of water was discontinued
 “one hour after it first begun. In 3 hours after I
 “saw him again; his face was turgid, his eyes inflamed,
 “his head dizzy, and his mind confused, with a pulse so
 “full and strong, as to demand copious ven. sectio. and a
 “strong cathartic of calomel and jalap. The blood
 “was buffy, and had a smaller proportion of serum
 “than natural. The next day he looked as spiritless,
 “feeble, and languid, as if he had just recovered from
 “a severe and tedious illness—he was not able to
 “return to work until after 21 days.”

The air to which this young man was exposed, was probably a combination of alkaline gas from the fæces and carbonic acid disengaged by the fermenting matters. This mixture, if such it was, has been proved by an experiment of M. Troja, to have an effect precisely similar to that of pure carbonic acid*; the happy recovery was undoubtedly owing to the application of cold water, so judiciously continued for that great length of time. When life was restored by this treatment, it is probable that the patient would again have sunk under the violent action of the arterial system, had it not been reduced by the liberal evacuations and other treatment of fever.

The application of cold and of cold water, which when long applied has proved so beneficial in cases of this kind, is by no means a remedy to which we are not familiar in similar affections. Children and the common people use this method of relieving persons who are found in that species of apoplexy which is known to be induced by the immoderate use of spiritous liquors, and which occasionally proceeds to such lengths as to be with difficulty distinguished from the true state. Ask them why they pump on, or pour cold water over persons thus affected, and they will tell you, to make

* See Rosier, p. 182.

them sober; that is, to reduce the excessive determination of arterial action to the brain, and thus permit the mind to resume its supreme dictatorial function, and the Nervous System its important office in the animal oeconomy.

The Russians and inhabitants of Siberia, we are told, have frequent occasion for assistance in cases of this kind, where charcoal fires are so largely employed. They drag persons motionless and apparently dead from the place in which they were exposed, and rub them with snow or ice, or dash cold water repeatedly over the whole surface of the body. This method, we are informed, is universally practised among the common people, and with constant success where respiration has not been suspended more than an hour*.

When ice cannot be procured, may not a refrigerating mixture by the solution of neutral salts be applied in bladders, so as effectually to answer every purpose? When neither this, nor ice, nor even water in sufficient quantities can be procured, let us not cease to exert ourselves in that most admirable, but too frequently least successful of all pursuits, viz. the restoration of life. Let us throw on what water we can get and expose the patient to a current of air, that the body being thus moistened, may be reduced in temperature by the evaporation: if not water, throw on spirits, alcohol, æther, or any other fluid which by a speedy evaporation may produce the necessary degree of cold.

Seeing this treatment so effectual as we are promised it will be, we may well be surprised that it has not been more commonly practised in relieving the different cases of apoplexy, in which little has been done except the liberal application of the lancet. Apoplexy, it is true, is not constantly relieved by these remedies.

I am disposed to believe, however, that apoplexy, as

* See Dr. Fothergill's excellent dissertation on the Suspension of Vital Action, p. 136.

well in ordinary cases, as from exposure to carbonic acid, &c. may be always relieved when the asphyxia is induced by congestion of blood in the brain, or by the distension of the vessels without the effusion of their contents; provided these remedies be persevered in a sufficient length of time: when effusion has taken place the success is very doubtful. In one case of a puppy where I failed of restoring life (perhaps by not continuing the cold long enough) I found, on dissecting the head, not only the blood-vessels all greatly distended, but likewise a quantity of red blood effused on the back part of the brain, between the dura and pia mater.

SECTION III.

The use of Carbonic Acid in the cure of Diseases.

HAVING seen the powerful effects of carbonic acid on the animal body while in health, we may immediately conclude that its agency in disease would not be less remarkable, and that like other substances of the same properties, it might be rendered, by modifying the quantity and varying its application, the instrument of life as well as death, of health equally with that of disease.

Accordingly we find by the industry and observation of several medical inquirers, that this article has been found most eminently serviceable in the cure of many affections to which the human body is liable. Thus a new branch is produced on the flourishing plant *Materia Medica*, which by its beauty, vigour, and analogical resemblance in nature and sensible properties, bids fair to prove with the advancement of science, one of the most valuable improvements in the healing art. This, with most of the gaseous fluids, the properties and uses of which have lately been investigated with much

accuracy, ingenuity, and care, will constitute a branch very properly denominated Pneumatic Medicine.

I now propose to inquire into the different kinds of disease, that have been treated with this gaseous substance and attended with beneficial influence, and explain the principle on which this is produced.

In cases of Typhus, the remedy the subject of our investigation, has been attended with effects the most evidently serviceable of any almost, on the record of medicine. Dr. Percival* and Dr. Dobson†, in the cases related of what they call putrid fevers, have proved this in the most pointed and decided manner possible. They describe cases of this kind, in which the disease had advanced so far as to be attended with Subsultus Tendinum, a brown fur on the tongue, frequent, fætid, and involuntary stools, a pulse from 120 to 135, delirium and even petechiæ, which were completely cured in the space of 5, 6, and 8 days by injections of carbonic acid into the rectum, and by permitting it to be disengaged in the stomach by the effervescing mixture.

A case of the same kind is published by Dr. Priestley‡, as communicated by Mr. Hey of Leeds. Here the usual treatment had been carried to its greatest extent, but the patient continued to grow worse; it was now attended with a violent putrid diarrhoea, as it is termed, and the patient was sinking under the discharge. Carbonic acid air was ordered to be injected into his rectum by means of the machine for injecting tobacco smoke; the heat and factor of his stools was at once removed, and in two days every symptom of danger disappeared.

These were unquestionably cases of that stage of fever which we now call the gangrenous, in which tonic and stimulating remedies are universally recom-

* See Vol. II. p. 313, 14.

† See Dobson on Fixed Air, p. 22. &c. &c.

‡ See the Appendix to Observations on Air, Vol. I. Also Rosier's Journal, Vol. I. for 1773.

mended, and as constantly found to be the only ones beneficial. The carbonic acid here must act by stimulating the stomach and rectum, and thus imparting the necessary degree of tone to the muscular fibre in the rest of the system. This explanation I advance, believing with Dr. Seybert, that no putrefaction can take place in the living body. I would therefore with Dr. Dickenson attribute the appearance of petechiæ, vibices, and maculæ, not to a putrefaction of the fluids, but to a weakness or loss of power in the muscular fibres of the capillary arteries, so as to permit them to be ruptured by the common impetus of the blood, and the effusion of red globules by this means to take place in the cellular membrane, affording the appearances from which the names are taken.

In confluent Small Pox and Cynanche Maligna, the former attended with black pustules, blisters of dark serum, petechiæ, and subsultus, the latter with deep ulcers in the throat, the fauces, tongue, and roof of the mouth covered with a black fordes, constant diarrhoea and violent phrenitis, Dr. Dobson tells us that complete relief was procured in a short time by carbonic acid disengaged in the stomach by a mixture of 1 and 2 scruples of mild vegetable alkali and 1-2 an ounce or an ounce of lemon juice, and this repeated every two or three hours.

When this treatment is required in children who cannot be made to take the mixture, the air may readily be thrown up by clyster, or the child may be held over an effervescing mixture for some length of time, permitting it to be inhaled occasionally.

In Dyspepsia, when attended with considerable anorexia, nausea, and eructation, we have well attested proof of carbonic acid being found highly serviceable; and this must be, without doubt, effected by the gratefully stimulating gas imparting that tone to the stomach, which renders it capable of executing its allotted functions.

In the nausea and vomiting, that distressing symptom of fever, so perplexing to physicians and discouraging

to patients, the saline effervescent mixture first recommended by Riverius has always been extolled among the most serviceable, if not as the most effectual of all medicines stiled antiemetics.

But here it may be asked if carbonic acid be a stimulant, how can it by that property check a vomiting, which must depend on too great a degree of irritation already seated in the stomach? In answer to this, I would first observe, that vomiting does not unfrequently depend on a debility, or want of power in the stomach to perform its proper office; and then its operation in the way suggested, will be sufficiently evident. But when the vomiting is excited by irritation, as I believe it generally is, the explanation must be considerably modified.

Daily experience evinces that substances acknowledged as stimulants, produce the same effects with carbonic acid, when used to relieve vomiting. It is well known that ardent spirits and opium, will relieve even the vomiting excited by tart. antimony, and we all believe them to be truly stimulant. The fact may, I think, be explained in two ways, either of which will be deemed sufficient. With Mr. J. Hunter, we may say that a new action is instituted by the carbonic acid, different from, and more salutary than that previously excited by the tart. antimony, or any similar cause. We may likewise explain it by believing, that the new stimulus determines the increased action or excitement, from that part of the stomach in which it was first seated, to another less irritable, and less intimately connected with the other parts of the body; from the cardia, for instance, in which it may produce vomiting, to the pilorus, in which the opposite effect would be most likely to follow. On the same principle we observe that a blister applied to the skin, during the violent pains that fly through the different parts of the body in inflammatory fever, give almost certain relief, by inviting the determination of the action to, and as it were, concentrating it in the skin, a part less sensible and less immediately connected with life, than the

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arterial system. The first of these, perhaps, will most generally be received; but I acknowledge that I can not conceive of one muscular fibre being capable of taking on so many different kinds or forms of contraction, (by which action must be effected) as the supporters of this opinion contend for; and therefore prefer the latter of the two opinions.

Dr. Percival recommends the exhibition of carbonic acid in sea-scurvy, schrophula, and in dropfy*. It is probably on this principle, that wort has been found of evident service in many scorbutic and schrophulous cases. The wort being a saccharine fluid, immediately enters into a state of fermentation, and disengages the acid.

In phthisis, carbonic acid inhaled into the lungs has been proved, by the industry and perseverance of Dr. Beddoes, and his friends, to be very powerfully efficacious in relieving the symptoms, and even perfecting the cure, if sufficiently diluted with atmospheric air, and inspired for a certain length of time each day. The Doctor explains its beneficial agency in these cases, as arising simply from the abstraction or diminution of oxigene in the air respired. This explanation is in part, I believe just; for he has likewise shown, that hydrogen and azote, when thus inspired, produced similar effects, which could only be from withholding oxigene, as they of themselves have no inherent action. But if it be found that carbonic acid applied to old ulcers, gives them a disposition to heal by stimulating the adjoining parts; and if it be believed that the ulcers of the lungs are of this dull and languid kind, from the nature of its substance; it will appear probable that carbonic acid is likewise beneficial, by

* It was observed uniformly in all my experiments with this acid taken into the body, that a great discharge of urine always took place: in a very short space of time, more than twice the quantity of fluid drank would be returned; from which circumstance, I suppose the impregnated water at least a very useful drink in cases of dropfy.

stimulating these ulcerated parts, and giving them a healthy degree of action.

In cases of affection from calculi, the exhibition of carbonic acid has been found so certainly beneficial, as to demand the most serious attention. In a case of this kind that came under my notice, the acidulous waters of Saratoga have produced such effects as to leave no doubt of their efficacy.

Mr. N. B. a respectable inhabitant of this city, had been afflicted with the stone for the space of 36 years, towards the last of which time, it was so troublesome as to oblige him to have his urine discharged for two months regularly, by means of a catheter; so violently attacked was he at times, as to have his life despaired of. With much difficulty he arrived at Saratoga, and on using the water as his constant and only drink, at the end of three weeks he was so perfectly restored, as to have no further symptoms of his being ever distressed. He continued thus free from every uneasiness for two years, at the end of which time he had one slight attack, which came on during the time of an inflammatory fever. It is now three years since the time of using the waters, and he has never had but the one return of his complaint. Even this appears probably to have been a symptom of stranguy, as a violent affection of his stomach took place as it abated. The Gentleman informed me that he drank the water in the quantity of gallons per day*.

From the experiments of Dr. Percival, we find that calculi are certainly dissolved in water thus impregnated; and from the experiment of Dr. Dobson, it is

* In the Medical Memoirs, Vol. I. p. 225, a case is related of Mr. John Hobman, in whom a stone was felt in drawing off his water with a catheter. He took twice a-day, with diluted vitriolic acid, a solution of salt of tartar highly saturated with carbonic acid, and after three weeks voided a great quantity of urine with a fine calculous matter; from which time he was freed from every symptom of the affection. He died about five years after, and being examined no remains whatever of calculous matter could be discovered,

proved that the urine of persons using the carbonic acid is largely impregnated with it; for from fresh urine of this kind, he procured 1-5th of its whole bulk in carbonic acid. Dr. Percival likewise informs us, that calculi infused in the urine of such persons, lost in weight or was in part dissolved, while the same in common urine increased in weight. If these circumstances come well attested, as they surely do, we can no longer doubt of carbonic acid being a solvent for the stone, and that it will not only relieve the symptoms, but actually remove the cause.

That carbonic acid would be very effectual in melancholia and depressions of the mind, we may reasonably conclude from its acting specifically on the brain. That this specific determination does take place, we have not only proofs from every experiment, but see it finely illustrated in the peculiar effects produced by Champagne wine on the mind. To what of its component parts, or which of them combined, can this effect be ascribed, unless to the carbonic acid? as we know that other wines with the same or a greater proportion of alcohol, with the same or a greater proportion of must or saccharine matter, and with the same proportion of other ingredients, will not produce effects by any means similar*.

It has been found that frogs, fish, and insects of their nature, will not live in water impregnated with carbonic acid; from which I would conclude, that drinks thus impregnated will prove of singular service in removing worms from the alimentary canal. I have been confirmed in this opinion by having observed that, in this city, and N. York, where the chief drink of the inhabitants is beer and porter, the children are much less commonly afflicted with worms, than in the southern states, where the inhabitants drink spiritous liquors in common, and employ but inconsiderable quantities of

* May not an excellent Champagne be readily prepared at any time, by impregnating a wine of the same apparent strength, &c. with carbonic acid, by means of Nooth's apparatus.

malted drinks. Worms are found to exist in those children especially, whose powers of digestion are most feeble; and are supposed to act as assistants in that process, till by their numbers or bulk, they produce uneasiness. Porter, beer, and ale, it is probable, will, by the tonic property of their bitter, promote an increased vigour of the stomach, while it destroys, by its carbonic air, the worms found in these passages.

Dr. Dobson has published many extraordinary instances of speedy cures being produced in long standing ulcers by the application of carbonic acid. In ulcers of the fauces, he effected the most immediate relief by giving the effervescing mixture, and by fumigating the part with carbonic air disengaged from chalk by vitrollic acid; it was even successful in a case attended with caries. Dr. Percival has likewise given cases of the same kind to prove its useful tendency; of these he describes one of a painful apthous ulcer, and recommends it in ulcerous sore throats.

Many cases are given by Dr. Beddoes which prove the efficacy of carbonic acid, not only in curing old and chronic ulcers, but likewise in putting a stop to gangrene, in relieving schrophulous ulcers and tumors, and even in checking the dreadful career of cancer and disarming it of its power. Carbonic acid in these cases is by no means a new remedy; its efficacy in the form of the yeast poultice has been long known and confirmed by frequent experience, before the principle was understood, on which the yeast acted*. Dr. Beddoes accounts for its beneficial effects in these cases, simply by the exclusion of oxigene; but this cannot be satisfactory, as the influence of oxigene may as effectually be excluded by other means as this. If we reflect that cancers are relieved, gangrene stopped, and

* Yeast has lately been recommended as an excellent cosmetic, to remove the troublesome pimples that so commonly appear in the face. See Beddoes on Factitious Air, p. 146.

chronic ulcers cured by the application of stimulating remedies alone; and if we remember that a property of this kind is most conspicuous in the operation of carbonic acid, we cannot be at a loss in explaining its operation from the influence of this principle. Carbonic acid or charcoal, the base of this gaseous fluid, has lately been strongly recommended in gangrene, in ichthrophula, and foetid ulcers, by Drs. W. Sandford, and John Johnstone, as published by Dr. Beddoes*; it promises, I think, to be a valuable remedy.

Much have I to regret, that the short time limited for preparing the matter of this dissertation, would not admit of my inquiring more minutely into the uses of carbonic acid, as a remedy for the afflictions of man; and into the comparative efficacy of the several proposed methods for relieving its baneful effects. Much remains to be done in this important branch of medical inquiry; for the great object of all our efforts is, and ever should be, the improvement of that science, which studies the prevention and cure of the many diseases to which mankind is subject.

The uses ascribed to carbonic acid, in the several affections above recited, are not simply the suggestions of visionary speculation; they are advanced as efficacious by the most plausible reasoning, supported by the strictest analogy, and confirmed by the most careful, accurate, and unbiassed experience.

To the much admired Medical Professors in this University, I am now thus publicly to offer my warmest, and most unfeigned professions of gratitude for the many favours, and the numerous instances of friendship which I have experienced in private. In public, your valuable lectures, from which I have derived the common benefit with my associates, must ever be

* See Factitious Air, p. 126, &c. I have taken, at different times, charcoal in fine powder to the quantity of 3 ii. My stomach being much afflicted with dyspepsia, I always found that it put a certain stop to the disagreeable acid eructations and cardialgia.

regarded as the great field from which I have reaped my present stock of professional knowledge.

To be particularly grateful to either, would be acting unjustly by the remainder—for you have all with paternal advice, and laudable precept, directed my pursuits, encouraged my labours, and promoted my advancement in the acquisition of truth. Long may you continue to receive the grateful acknowledgments of your pupils, and to be regarded as their respected Instructors, while you remain the Patrons of Industry, and the Promoters of Medical Science.

THE END.